

What is claimed is:

1 1. A memory management apparatus for accessing a physical page
2 mapped according to mapping information to a logical page that
3 includes a logical address specified by an access request, the
4 mapping information showing a one-to-one mapping between a
5 plurality of logical pages and a plurality of physical pages,
6 the logical pages being defined by dividing a logical address
7 space by a predetermined size, each of the physical pages
8 functioning to physically retain data of the predetermined size
9 and degrading in storage performance each time an access is made
10 thereto, the apparatus comprising:

11 an access frequency index storage unit operable to store
12 an access frequency index for each logical page, the access
13 frequency index indicating an occurrence frequency of an access
14 request specifying a logical address included in a corresponding
15 logical page;

16 a degradation index storage unit operable to store a
17 degradation index for each physical page, the degradation index
18 indicating a degree of degradation in storage performance of
19 a corresponding physical page; and

20 a degradation leveling unit operable to (i) exchange
21 retained data between a first physical page and a second physical
22 page, the first physical page being mapped according to the
23 mapping information to a specific logical page of which an access
24 frequency index is greater than or equal to a first threshold,
25 and the second physical page having a degradation index that

26 is less than or equal to a second threshold, and (ii) update
27 the mapping information so as to show that the specific logical
28 page is mapped to the second physical page.

1 2. The memory management apparatus according to Claim 1, further
2 comprising:

3 a cache storage unit operable to store, for each of up
4 to a predetermined number of the physical pages, cache data that
5 is a copy of data retained in a corresponding physical page and
6 that is accessed instead of the original data, and to write,
7 if cache data has been modified as a result of a subsequent access,
8 the modified cache data back to a corresponding physical page;
9 and

10 a degradation index updating unit operable to add a first
11 value to a degradation index of each physical page that retains
12 original data of cache data stored in the cache storage unit,
13 and add a second value to a degradation index of each physical
14 page to which modified cache data has been written back.

1 3. The memory management apparatus according to Claim 2, wherein
2 the degradation index updating unit adds, at a time when
3 cache data is invalidated or replaced by data retained in another
4 physical page, a sum of the first value and the second value
5 to a degradation index of a physical page storing original data
6 of the cache data if the cache data has been modified, and adds
7 the first value to the degradation index if the cache data has
8 not been modified.

1 4. The memory management apparatus according to Claim 2, further
2 comprising

3 an access frequency index updating unit operable to add
4 the first value to an access frequency index of a logical page
5 that is mapped according to the mapping information to each
6 physical page retaining original data of cache data stored in
7 the cache storage unit, and to add the second value to an access
8 frequency index of a logical page that is mapped according to
9 the mapping information to each physical page to which modified
10 cache data has been written back.

1 5. The memory management apparatus according to Claim 4, wherein
2 the access frequency index updating unit adds, at a time
3 when cache data is invalidated or replaced by data retained in
4 another physical page, a sum of the first value and the second
5 value to an access frequency index of a logical page that is
6 mapped according to the mapping information to a physical page
7 retaining original data of the cache data if the cache data has
8 been modified, and adds the first value to the access frequency
9 index if the cache data has not been modified.

1 6. The memory management apparatus according to Claim 2, wherein
2 the cache data storage unit further stores, at a time of
3 storing cache data, a cache access frequency index for the cache
4 data, an initial value of the cache access frequency index being
5 set to "0",
6 the memory management apparatus further comprising:

7 a cache access frequency index updating unit operable to
8 increment a cache access frequency index of cache data in response
9 to an access to the cache data; and
10 an access frequency index updating unit operable to compare,
11 for each piece of cache data, (i) an access frequency index of
12 a logical page that is mapped according to the mapping information
13 to a physical page retaining original data of a corresponding
14 piece of cache data and (ii) a cache access frequency index of
15 the corresponding piece of cache data, and to update the access
16 frequency index with the cache access frequency index if the
17 cache access frequency index is greater than the access frequency
18 index.

1 7. The memory management apparatus according to Claim 6, wherein
2 the access frequency index updating unit performs the
3 update at predetermined time intervals and resets all the cache
4 access frequency indexes to "0".

1 8. The memory management apparatus according to Claim 6, wherein
2 the access frequency index updating unit calculates, for
3 each piece of cache data, a normalized cache access frequency
4 index by normalizing a cache access frequency index based on
5 a time period during which a corresponding piece of cache data
6 is retained in the cache storage unit, compares the normalized
7 cache access frequency index and an access frequency index of
8 a logical page mapped according to the mapping information to
9 a physical page storing original data of the corresponding piece

10 of cache data, and updates the access frequency index with the
11 normalized cache access frequency index if the normalized cache
12 access frequency index is greater than the access frequency
13 index.

1 9. The memory management apparatus according to Claim 1, wherein
2 each logical page has a generic logical address that is
3 included in a corresponding logical page,

4 the memory management apparatus further comprising:
5 a detecting unit operable to detect an access request
6 specifying any of the generic logical addresses;
7 a degradation index updating unit operable to increment
8 a degradation index of a physical page mapped according to the
9 mapping information to a logical page that includes a generic
10 logical address specified by an access request detected by the
11 detecting unit; and

12 an access frequency index updating unit operable to
13 increment an access frequency index of the logical page that
14 includes the generic logical address specified by the detected
15 access request.

1 10. The memory management apparatus according to Claim 9, wherein
2 each generic logical address is a logical address that
3 is accessed whenever a logical page including a corresponding
4 generic logical address is accessed.

1 11. The memory management apparatus according to Claim 1, wherein

2 each physical page is implemented by a ferroelectric random
3 access memory.

1 12. A memory management apparatus for accessing a physical page
2 mapped according to mapping information to a logical page that
3 includes a logical address specified by an access request, the
4 mapping information showing a one-to-one mapping between a
5 plurality of logical pages and a plurality of physical pages,
6 the logical pages being defined by dividing a logical address
7 space by a predetermined size, each of the physical pages
8 functioning to physically retain data of the predetermined size
9 and degrading in storage performance each time an access is made
10 thereto, the apparatus comprising:

11 an access frequency index storage unit operable to store
12 an access frequency index for each logical page, the access
13 frequency index indicating an occurrence frequency of an access
14 request specifying a logical address included in a corresponding
15 logical page;

16 a cache storage unit operable to store cache data for each
17 of up to a predetermined number of the physical pages in
18 association with a replication access frequency index that is
19 a copy of an access frequency index of a logical page mapped
20 according to the mapping information to a corresponding physical
21 page, the cache data being a copy of data retained in the
22 corresponding physical page and that is accessed instead of the
23 original data; and

24 a degradation leveling unit operable, when one of the

25 pieces of cache data needs to be replaced with data retained
26 in a new physical page, to replace cache data associated with
27 a replication access frequency index that is less than or equal
28 to an access frequency index of a logical page mapped according
29 to the mapping information to the new physical page.

1 13. The memory management apparatus according to Claim 12,
2 further comprising

3 a replication access frequency index updating unit
4 operable, in response to an access to cache data, to decrement
5 a replication access frequency index associated with the cache
6 data.

1 14. The memory management apparatus according to Claim 12,
2 wherein

3 each physical page is implemented by a ferroelectric random
4 access memory.

1 15. A memory management method for accessing a physical page
2 mapped according to mapping information to a logical page that
3 includes a logical address specified by an access request, the
4 mapping information showing a one-to-one mapping between a
5 plurality of logical pages and a plurality of physical pages,
6 the logical pages being defined by dividing a logical address
7 space by a predetermined size, each of the physical pages
8 functioning to physically retain data of the predetermined size
9 and degrading in storage performance each time an access is made

10 thereto, wherein

11 the method employs (i) an access frequency index indicating,
12 for each logical page, an occurrence frequency of an access
13 request specifying a logical address included in a corresponding
14 logical page and (ii) a degradation index indicating, for each
15 physical page, a degree of degradation in storage performance
16 of a corresponding physical page,

17 the method comprising:

18 a degradation leveling step of (i) exchanging retained
19 data between a first physical page and a second physical page,
20 the first physical page being mapped according to the mapping
21 information to a specific logical page of which an access
22 frequency index is greater than or equal to a first threshold,
23 and the second physical page having a degradation index that
24 is less than or equal to a second threshold, and (ii) updating
25 the mapping information so as to show that the specific logical
26 page is mapped to the second physical page.

1 16. The memory management method according to Claim 15, further
2 comprising:

3 a cache managing step of storing, for each of up to a
4 predetermined number of the physical pages, cache data that is
5 a copy of data retained in a corresponding physical page and
6 that is accessed instead of the original data, and of writing,
7 if cache data has been modified as a result of a subsequent access,
8 the modified cache data back to a corresponding physical page;
9 and

10 a degradation index updating step of adding a first value
11 to a degradation index of each physical page that retains original
12 data of cache data stored in the cache storage step, and adding
13 a second value to a degradation index of each physical page to
14 which modified cache data has been written back.

1 17. The memory management method according to Claim 15, wherein
2 each logical page has a generic logical address that is
3 included in a corresponding logical page,
4 the memory management method further comprising:
5 a detecting step of detecting an access request specifying
6 any of the generic logical addresses;
7 a degradation index updating step of incrementing a
8 degradation index of a physical page mapped according to the
9 mapping information to a logical page that includes a generic
10 logical address specified by an access request detected in the
11 detecting step; and
12 an access frequency index updating step of incrementing
13 an access frequency index of the logical page that includes the
14 generic logical address specified by the detected access request.

1 18. A memory management method for accessing a physical page
2 mapped according to mapping information to a logical page that
3 includes a logical address specified by an access request, the
4 mapping information showing a one-to-one mapping between a
5 plurality of logical pages and a plurality of physical pages,
6 the logical pages being defined by dividing a logical address

7 space by a predetermined size, each of the physical pages
8 functioning to physically retain data of the predetermined size
9 and degrading in storage performance each time an access is made
10 thereto, wherein

11 the method employs (i) an access frequency index indicating,
12 for each logical page, an occurrence frequency of an access
13 request specifying a logical address included in a corresponding
14 logical page and (ii) a degradation index indicating, for each
15 physical page, a degree of degradation in storage performance
16 of a corresponding physical page,

17 the method comprising:

18 a cache storing step of storing cache data for each of
19 up to a predetermined number of the physical pages in association
20 with a replication access frequency index that is a copy of an
21 access frequency index of a logical page mapped according to
22 the mapping information to a corresponding physical page, the
23 cache data being a copy of data retained in the corresponding
24 physical page and that is accessed instead of the original data;
25 and

26 a degradation leveling step of, when one of the pieces
27 of cache data needs to be replaced with data retained in a new
28 physical page, replacing cache data associated with a replication
29 access frequency index that is less than or equal to an access
30 frequency index of a logical page mapped according to the mapping
31 information to the new physical page.